Exercise

1. The intrinsic carrier concentration o germanium (Ge) is expressed as

$$n_i = 1.66 \times 10^{15} T^{3/2} \exp \frac{-Eg}{2kT} \text{ cm}^{-3}, \quad (1.123)$$

Where $E_g = 0.66$ eV

(a) Calculate n_i at 300^0 K and 600^0 K and compare the results with those obtained in Example 2.1 for Si.
(b) Determine the electron and hole concentrations if Ge is doped with P at a density of 5 x 10^{16} cm-^{3}.

2. An n-type piece of silicon experiences an electric field equal to 0.1 *V/μm*. (a) Calculate the velocity of electrons and holes in this material (b) What doping level is necessary to provide a current density of *1mA/μm*^{2} under these conditions? Assume the hole current is negligible.

3. A n-type piece of silicon with a length of 0.1μ *m* and a cross section area of *0.05μm x 0.05μm* sustains a voltage difference of 1 V.

(a) If the doping level is 10^{17} cm-^{3}, calculate the total current flowing through the device at *T*= 300°K.

(b) Repeat (a) for *T* = 400^{0}K assuming for simplicity that mobility does not change with temperature.

4. From the data in Problem 1, repeat Problem 3 for Ge. Assume $\mu_n = 3900$ cm^2/(V. s) and $\mu_p = 1900$ cm^2/(V.s)

5. Figure 1.37 shows a p-type bar of silicon that is subjected to electron injection from the left and hole injection from the right. Determine the total current flowing through the device if the cross section area is equal to 1 µm x 1 µm.

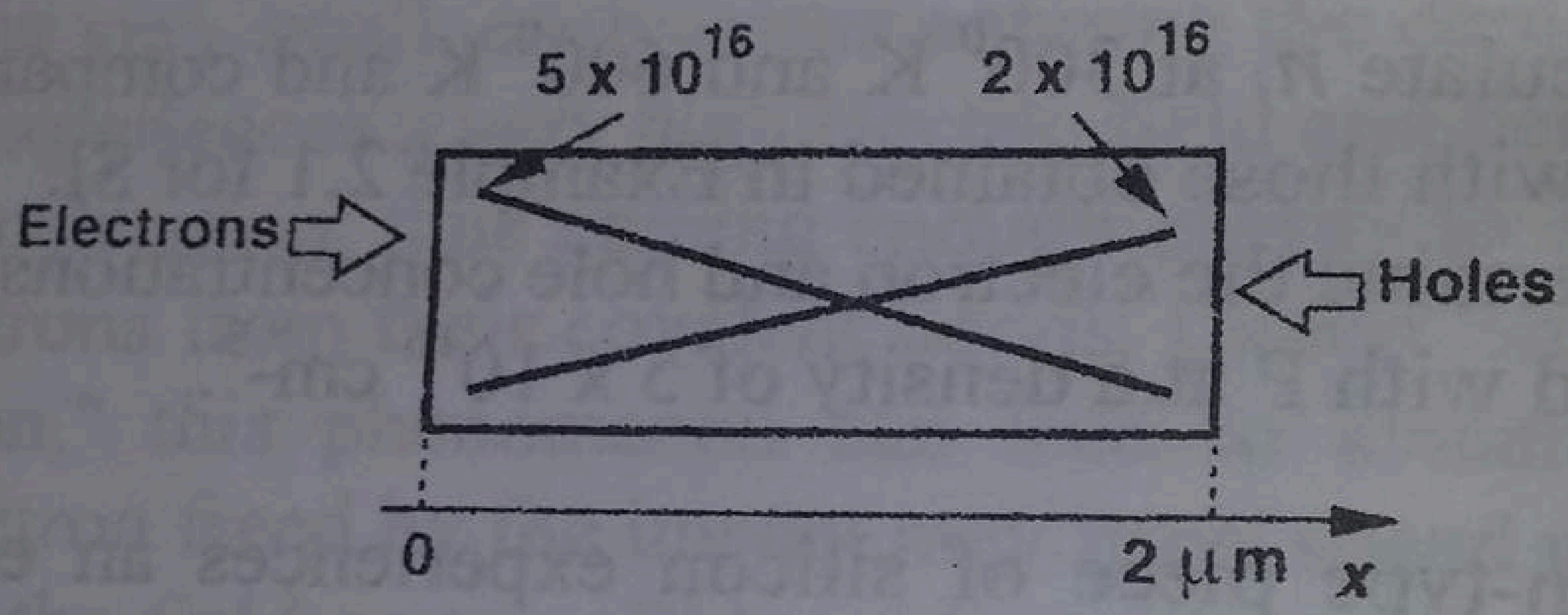

Fig 1.37

6. In Example 1.9, compute the total number of electrons "stored" in the material from $x = 0$ to $x = L$. Assume the cross section area of the bar is equal to a.
7. Repeat Problem 6 for Example 1.10 but for $x = 0$ to $x = \infty$. Compare the results for linear and exponential profiles.
8. Repeat Problem 7 if the electron and hole profiles are "sharp" exponentials, i.e., they fall to negligible values at $x = 2$ µm and $x = 0$, respectively (Fig. 1.38).

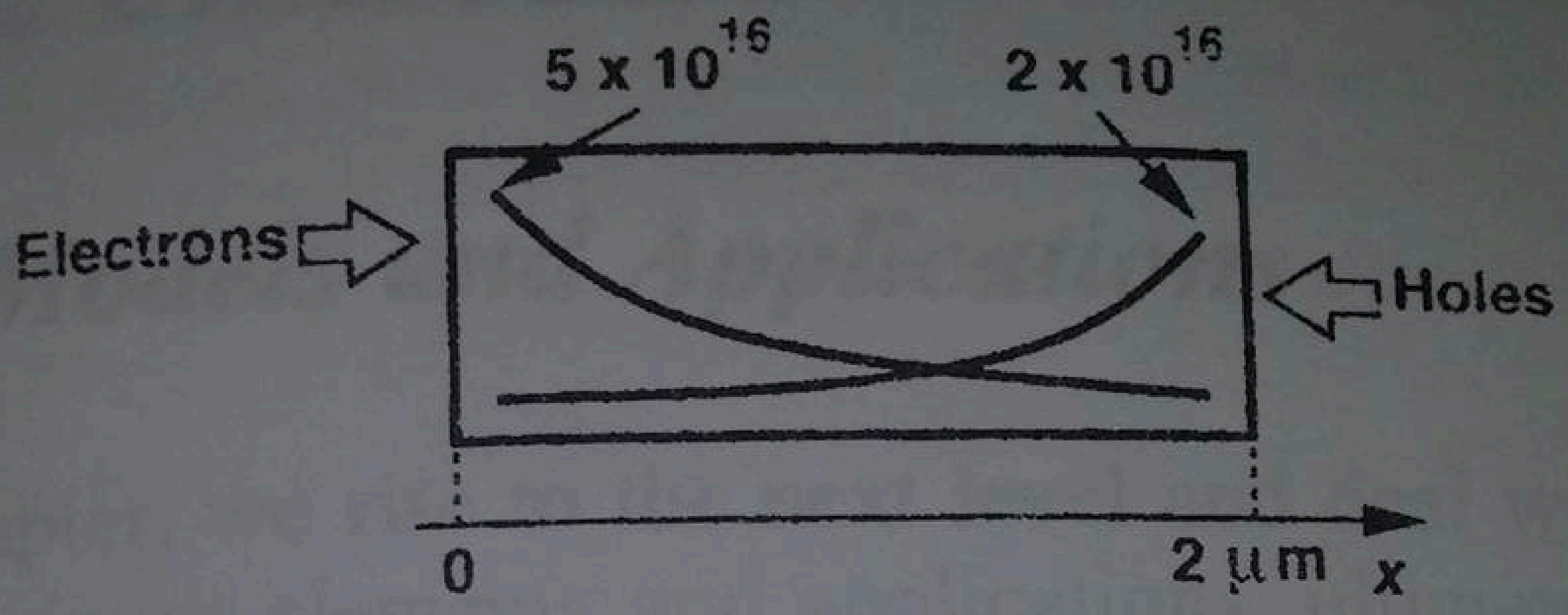

Fig 1.38

9. A junction employs $N_D = 5 \text{ X } 10^{17}$ cm^{-3} and $N_A = 4$ x 10^{16} cm-^{3}.

(a) Determine the majority and minority carrier concentrations on both sides.

(b) Calculate the built-in potential at $T = 250^0$ K, 300^0 K, and 350^0 K. Explain the trend.

10. Due to a manufacturing error, the p-side of a *pn* junction has not been doped.If $N_D = 3 \text{ x} 10^{16}$ cm^{-3}, calculate the built-in potential at $T = 300^0$ K.